Final Report

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

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ENERGY RETROFIT
JOHNSTON HOUSE
FREDERICTON, N.B.

CREDA PROJECT # 2036

February, 1985

Report Prepared by:
New Brunswick Energy Secretariat

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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D I S C L A I M E R

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D E N I D E R E S P O N S A B I L I T E

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1.0 EXECUTIVE SUMMARY

The Johnston House Commercial Energy Retrofit involved the modernization of an 1860's residence to usable office space. This was accomplished without altering the exterior appearance of the building.

The project has been successful in demonstrating the value of retrofitting older structures to modern office space. In addition to preserving the historic value of the building, the conversion process has provided city core office space at rates less than existing rentals and much less than new construction, assuming real estate can be purchased.

The goal of eliminating oil consumption and converting the existing building into an energy efficient structure has been achieved. Energy savings of $1000/yr. have been achieved. The space heating of 17 kWh/sq. ft. is very respectable given the age of the building.

1.0 SOMMAIRE RECOMMANDATION

Le rattrapage énergétique commercial de la maison Johnston comportait la modernisation d'une résidence de 1860 en un immeuble à bureaux. Les travaux ont été réalisés sans modifier l'apparance extérieure du bâtiment.

Le projet a servi à démontrer l'intérêt du rattrapage d'anciens bâtiments en immeubles à bureaux modernes. En plus de préserver la valeur historique du bâtiment, le processus de conversion a permis de doter le centre-ville de nouveaux espaces à bureaux dont le prix de location est moindre que dans les bâtiments existants et de beaucoup inférieur à celui des bureaux situés dans les nouvelles constructions, à la condition de pouvoir trouver un terrain pour les y construire.

On a réussi à éliminer la consommation de mazout et à convertir le bâtiment existant en une structure à haute efficacité énergétique. Les économies d'énergie se chiffrent à 1000 $ par an.

Compte tenu de l'âge du bâtiments, le taux de 17 kWh/pi^2 pour le chauffage des locaux est bien raisonnable.

2.0 INTRODUCTION AND BACKGROUND

In 1981, the New Brunswick Energy Secretariat found itself in need of additional office space. Several possibilities were explored and the conversion of an existing building to modern office space was decided upon. The building, at 124 St. John Street in downtown Fredericton had been owned by the Provincial Government for several years and was deemed to have significant architectural value.

A procedure was established to convert the building to modern offices internally while maintaining or, in some cases, restoring the exterior architectural details. The project was to incorporate some structural changes, insulation to high RSI values, new glazing, and several energy related systems. Overall, the interior space was redivided with the re-positioning secured by reversing the main hall staircase and adding a space-saving circular staircase in the rear. Other interior work was straight-forward: remove plaster and lath, increase stud-bay depth, re-insulate, add vapour barrier then add new plaster board.

3.0 GENERAL DESCRIPTION OF DEMONSTRATION

The office building provides 1500 sq. ft. (139 sq. m.) of high quality office space (excluding hallways, lavatories). This has been used to provide upwards of 14 work stations.

The retrofit project can be detailed by examining the various areas of work completed.

- **Structural:** Reversed main hall stairway to provide basement access outside occupied space; replaced rear staircase with spiral unit. In basement, load-bearing columns were secured and floors re-leveled where appropriate. In rear part of the building, which had no basement, the ceiling of the downstairs was reinforced to ensure safety of upstairs loft area. The stone foundation was repaired in the areas where mortar had deteriorated over the years.

- **Building Envelope:** In the basement, damp proofing was carried out, then the walls were studded, insulated, a vapour barrier installed then sheathed in gyproc.

  On the main levels of the building, outside walls were of plaster and lath. The stud bays were deepened to allow R20 (RSI 3.5) fibreglass to be installed. All walls received a continuous vapour barrier which was sealed at joints and electrical utility boxes. From the attic, the roof areas had vapour barriers installed on the "warm-in-winter" side and sealed before being insulated to R40 (RSI-7).

To preserve the character of the building, all windows were replicated in a local woodworking shop. The major difference was the substitution of thermal double glazing for the old single glazing in all windows.

All entrance doors installed are insulated steel units.

- **Building Equipment**: Major changes to the heating system were made during retrofitting. The oil-fired furnace was replaced by an electric-forced air furnace. Ducting was installed such that any desired quantity of outside air can be circulated through the house. In addition, an electronic air cleaner was installed as well as an adjustable humidifier and provision for a future heat-pump air conditioner.

  The heating system is completely zoned; that is, each office thermostat controls a distribution damper so that individual occupants can maintain their comfort levels without affecting other persons in the building. An automatic setback feature was included to lower building temperatures after work hours and on weekends.

  In the rear portion of the building, electric baseboard heat was installed to simplify the installation of heating ducts to other parts of the building. Each area served by electric baseboard heaters is controlled by a setback thermostat which allows lower temperatures when the areas are unoccupied.

To minimize hot water costs at each of four stations requiring hot water, instantaneous water heaters were installed. These units provide water for hand washing without the stand-by losses associated with conventional hot water tanks.

To ensure sufficient fresh air during the winter months when the furnace might be using 100% recirculated air, an air-to-air heat exchanger was ducted to the furnace. The intakes to the exchanger are in the two lavatories and operate the exchanger fans when the lavatory lights are on.

- **Heat Pump**: A Lennox air-to-air heat pump was installed in the latter stages of the project. It has operated quite efficiently and supplies most of the building's heat requirements. Due to time limitations no monitoring is available on the heat pump system.

4.0 OBSERVATIONS DURING INSTALLATION AND MONITORING

Because all work on the building was contracted to professional tradesmen few major problems were encountered during the retrofit.

Monitoring of the project required the installation of several pieces of additional equipment, chiefly electrical, to ensure the monitoring of various building electrical consumptions. The systems which were isolated included:

- separate kilowatt-hour meters for heating coil in furnace, furnace blower motor, lighting systems consumption, consumption of miscellaneous receptacles and office equipment, hot water heater consumption;

- Annual electrical consumption after retrofit is 40,620* kWh. From the monitoring, this number can be broken down into specific consumptions. (See Appendix 3 for details)

Heating	=	37 848 kWh/yr
Lighting	=	2 080 kWh/yr
Domestic Hot Water	=	42 kWh/yr
Miscellaneous	=	650 kWh/yr
TOTAL		40 620 kWh/yr

* N.B. Power Bills
April '83 - March '84

The energy budget for Johnston House is as follows: (See Appendix 3 for detailed information).

Heating	=	19.6 kWh/sq.ft.
Lighting	=	0.9 kWh/sq.ft.
Domestic Hot Water	=	0.02 kWh/sq.ft.
Miscellaneous	=	0.3 kWh/sq.ft.
TOTAL		20.82 kWh/sq.ft.

This figure is very respectable given the age of the structure. The most energy efficient commercial office space of new construction has an energy budget of approximately 13 kWh/sq.ft. Therefore, 20.82 kWh/sq.ft. compares favorably with most modern office space.

5.0 COST BENEFIT ANALYSIS

The costs for the retrofit are summarized below:

Energy Retrofit	Labour & Material
1. Insulation of walls and roof to R20 (RSI 3.5)	$ 8,000
2. Glazing	4,500
3. Air lock entry	2,000
4. Air to air heat exchangers	1,500
5. Energy efficient control systems	1,000
6. Plumbing - control flow devices and DHW heaters	2,500
7. Task lighting system c/w controls	4,000
8. Heat Pump	4,218
9. Contingency	5,000
Sub Total	$32,718

Energy Systems Performance Monitoring (1 yr.)	
1. Supply and installation of monitoring and metering equipment	$ 3,732
2. Progress Reporting	1,000
Sub Total	$ 4,732

Information Transfer	
1. Final Report	1,500
2. Slide presentation package	700
Sub Total	$ 2,200
Total	$39,650

Cost Benefit (Con't)

Simple payback calculation:

Cost of retrofit (less information transfer, contingency, monitoring and heat pump)	$39,650 - 16,150 = 23,500
Energy costs before retrofit (oil)*	$4,220/yr ($.308/L)
Energy costs after retrofit (electricity) 37,848 kWh x ($0.079/kWh)	$2,990/yr
Saving per year	$1,230
Payback	$\frac{23500}{\$1,230}$ = 19 years

The value of retrofits of this type can be looked at in a number of ways. In addition to a simple payback analysis, it would be useful to consider local conditions and their effect on the retrofit decision.

For example, at the time this project was considered, leased space in Fredericton was in the range of $7.92 to $10.10 per sq. ft.

A leased space at the time would have cost $23,237.13 per year plus a one-time cost of $23,000. Over five years, the leasing costs would total $139,185.65.

* from historical data

The cost of the retrofit plus the fair market price for the property in question was $110,400.00. With these figures, a second pay-back might be considered.

Average yearly cost of leased space $139,185.70/5 = $27,837

Cost of old building plus retrofit $110,400.00

$$\frac{\text{cost of bldg. \& retrofit}}{\text{equivalent rent/year}} = \frac{110,400.00}{27,837} = 3.96 = 4 \text{ years}$$

For the equivalent of paying rent for four years, the property can be owned outright. Naturally the costs of operation will lengthen the payback. Experience under leasing arrangements shows that electricity, taxes, cleaning, operating expenses will amount to about $3.34 per sq. ft. per year.

To provide offices equivalent to Johnston House, at 2300 gross sq. ft. this amounts to (2300 X 3.34) = $7,682 per year. Now a more realistic payback can be calculated.

$$\frac{110,400 + (5 \times \$7682)}{27,837} = \frac{148,810}{27,837} = 5.34 \text{ years}$$

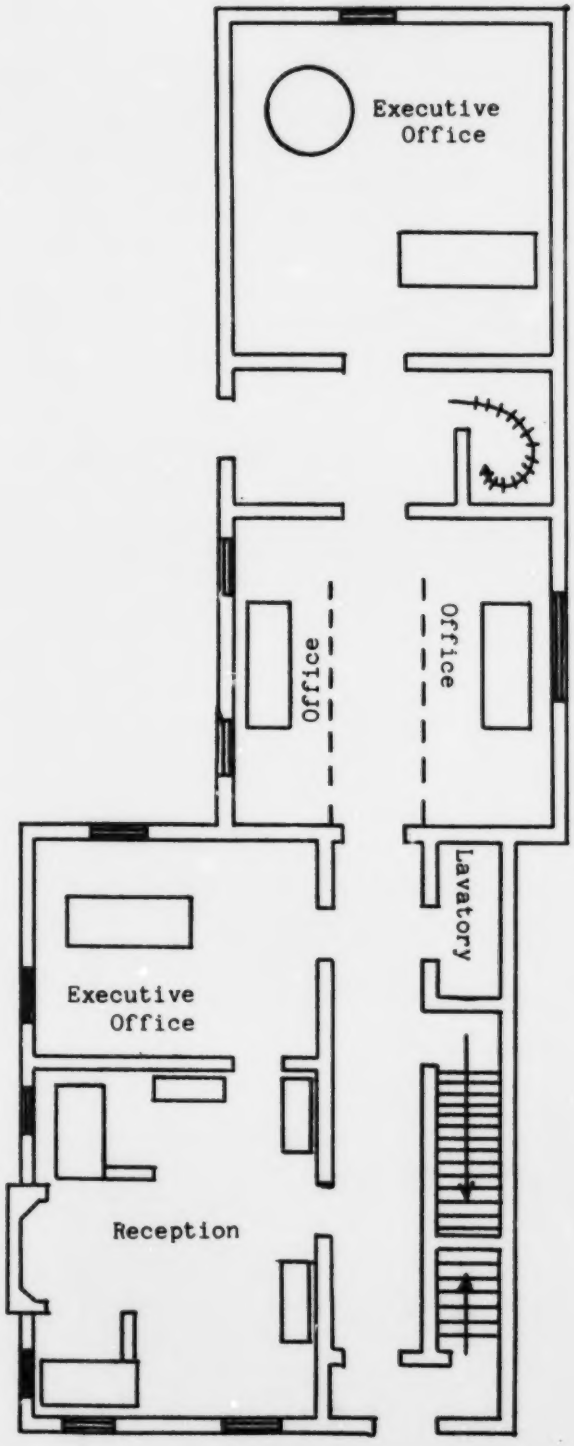
6.0 CONCLUSIONS AND RECOMMENDATIONS

It has been shown that the option of retrofitting older structures should be considered for persons seeking attractive, downtown office space. The retrofitting of historic buildings provides a viable alternative to destroying the buildings while making them economical for their owners/tenants. Significant energy savings have been achieved by retrofitting the building. This project has shown the viability of converting older residential homes into energy efficient office space.

A P P E N D I X

APPENDIX 1.

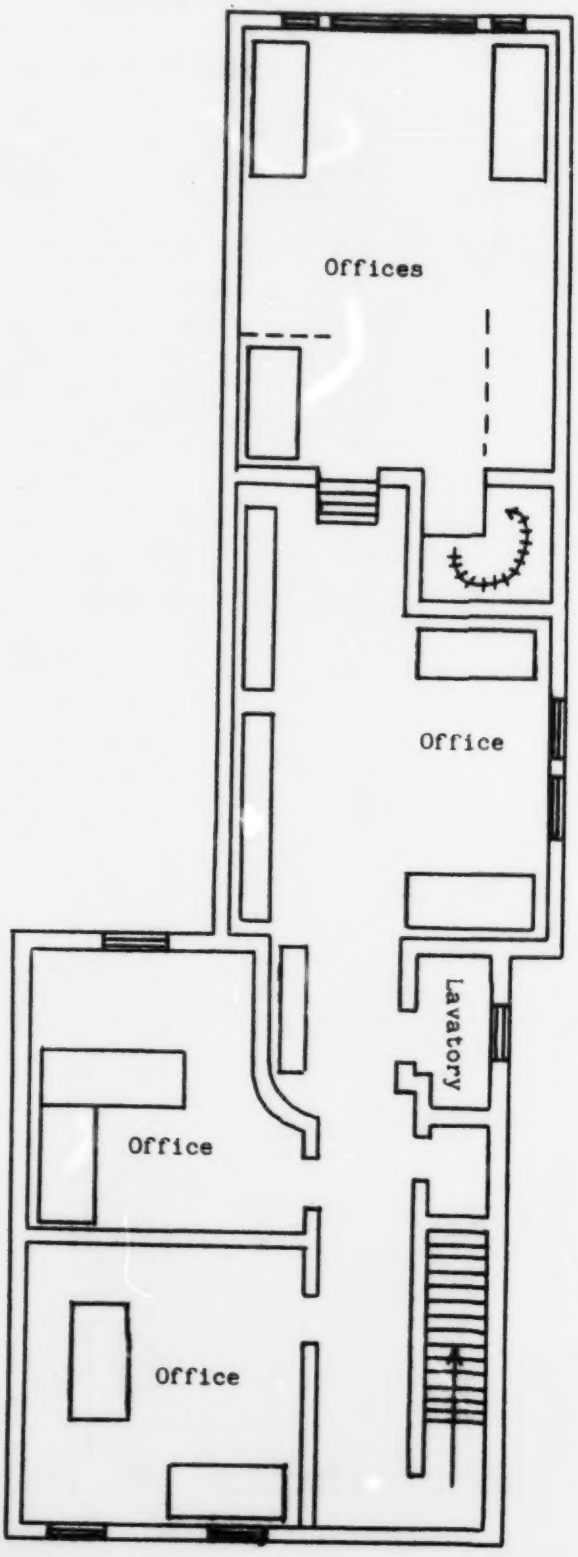
Building floor plan as constructed.



MAIN FLOOR

APPENDIX 1

Building floor plan as constructed.



SECOND FLOOR

Appendix 2

Performance Monitoring Plan

Energy Systems Performance Monitoring Plan

Project Title: ENERGY EFFICIENT COMMERCIAL RETROFIT - JOHNSTON HOUSE

Person Responsible for Performance Monitoring:
(Professional Engineer or Certified Engineering Technologist)

Description of Monitoring System:
Identify instruments and transducers to be used, proposed measuring intervals, etc.

The following systems will be monitored and/or energy consumption measured for a full twelve-month period.

1. Outdoor ambient temperature (^{o}c)
2. Indoor dry-bulb temperature (^{o}c)
3. Kilowatt-hour consumption of electric heating coil in furnace (KWH)
4. Consumption of blower motor on furnace (KW)
5. Lighting systems consumption (KWH) & operating times
6. Miscellaneous power for receptacles, office equipment, etc.(KWH
7. Instantaneous hot water heaters (KWH)
8. Domestic hot water (liters per day)
9. Total water consumption (liters per day)

List of Monitoring (Measuring) Equipment to be Used:

Equipment	Manufacturer	Model Number
KWH - Demand Meters		
Hour Meters		
Water Meters	Neptune	Trident 8
Temperature Sensors	Honeywell	
& Indicating Gauges		

System Schematic Diagram:
Please indicate monitoring layout, including location of transducers, instruments, etc.

Summary of Calculations to be Performed:
List the detailed calculations to be made on the measured data which will determine the energy efficiency of the system being demonstrated. (SI units of measurement are preferred but are not mandatory.)

An energy budget was prepared for the building based upon calculations for heating, lighting, miscellaneous power and domestic hot water consumption.

The energy budget was established as follows:

1. Heating	7.5 KWH/Sq. Ft.
2. Lighting	1.8 KWH/Sq. Ft.
3. Domestic Hot Water	0.5 KWH/Sq. Ft.
4. Misc. Power	1.3 KWH/Sq. Ft.
TOTAL ENERGY BUDGET	11.1 KWH/Sq. Ft.

Comparisons will be made with other office space and the measured energy efficiency of the project will be reported in the final report.

Appendix 3

Performance Monitoring

The following graphs indicate readings taken during the month of June 1982 for lighting, domestic hot water and miscellaneous usage. The consumptions stay constant throughout the year, therefore, using June as a representative month, the average daily consumption for each can be calculated. From this a fairly accurate yearly consumption for lighting, domestic hot water and miscellaneous power can be calculated. By subtracting these yearly consumptions from the monthly power bills for the year, the amount of energy spent on space heating can be found.

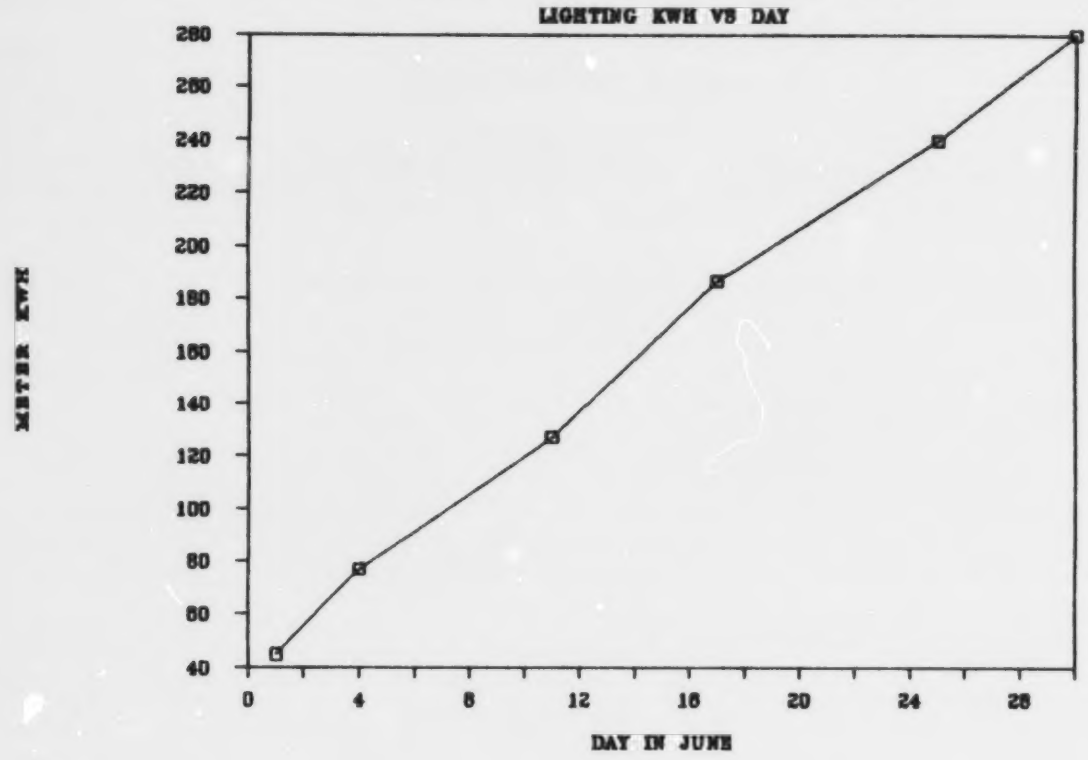
$$\text{Space Heating} = \text{yearly kwh consumption} - \text{lighting} - \text{DHW} - \text{Miscellaneous}$$

$$= 40{,}620 - 2080 - 42 - 650$$

$$= 37{,}848 \text{ kwh}$$

$$\text{Space Heating} = \frac{37{,}848 \text{ kwh}}{2300 \text{ sq. ft.}} = 16.5 \text{ kwh/sq. ft.}$$

JOHNSTON HOUSE – JUNE 1982



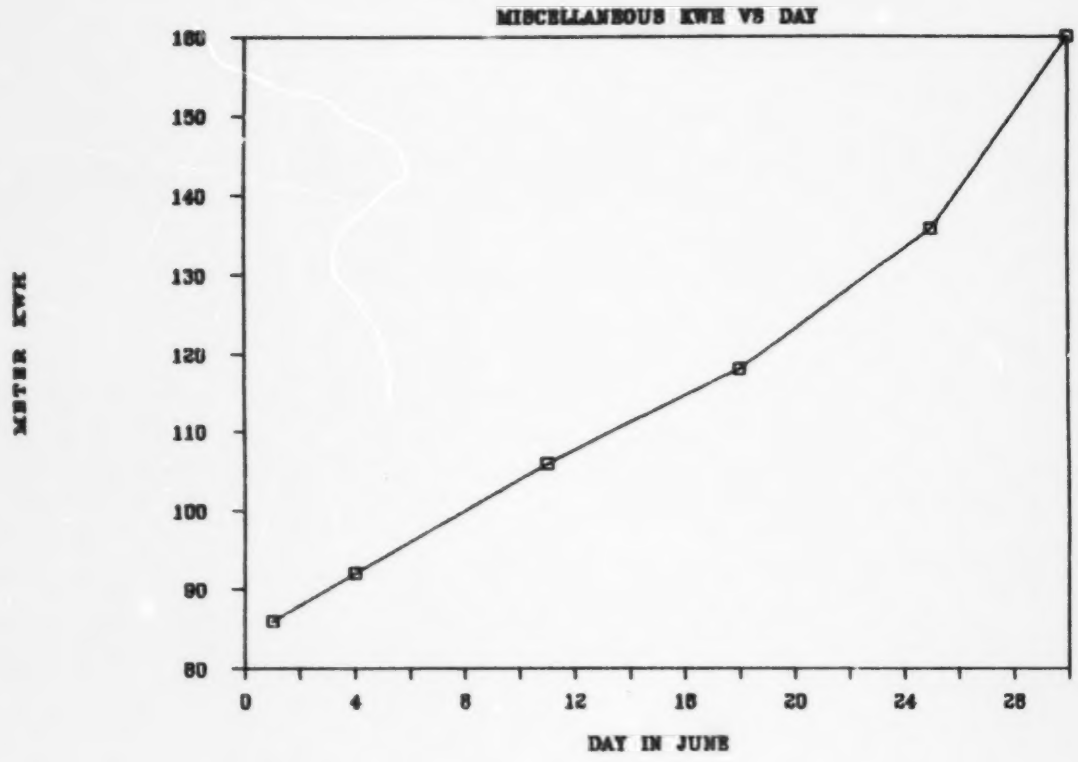
Average Daily Consumption = $\frac{280 - 40}{30}$ = 8 kwh/day

Yearly Consumption = 8 kwh X 260 (working days)

= 2 080 kwh/yr

= $\frac{2\ 080}{2\ 300}$ = 0.9 kwh/ft^2

JOHNSTON HOUSE - JUNE 1982



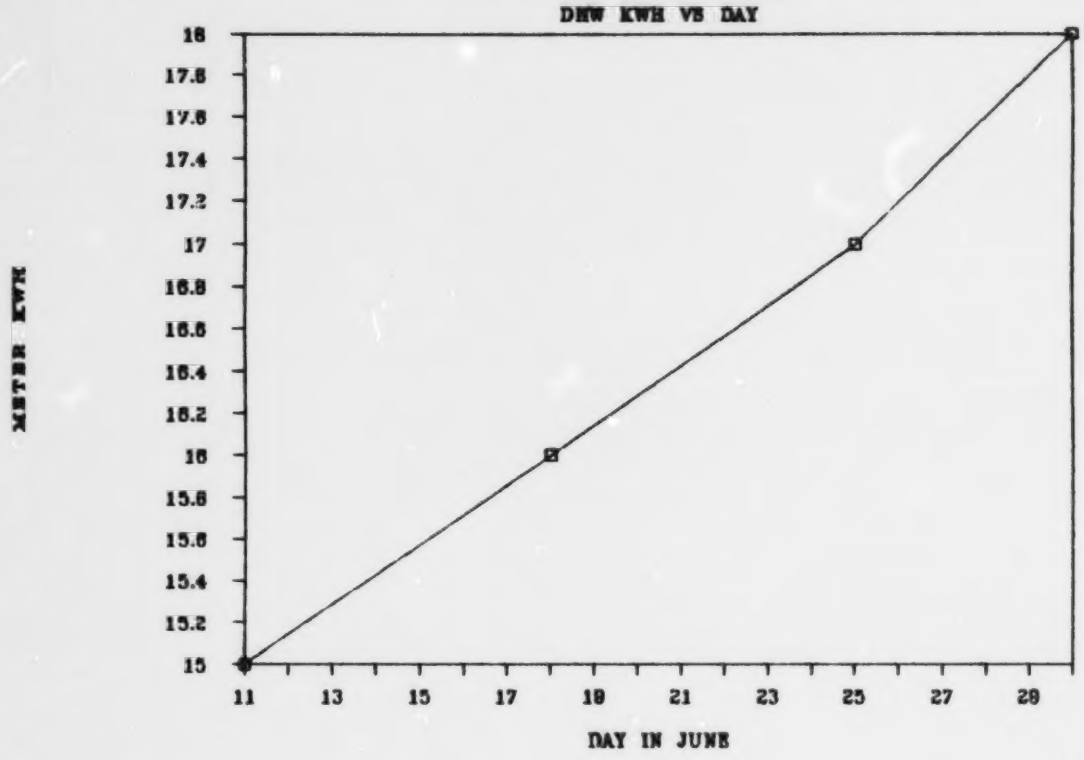
Average Daily Consumption = $\frac{160 - 85}{30}$ = 2.5 kwh/day

Yearly Consumption = 2.5 kwh X 260 (working days)

= 650 kwh/year

= $\frac{650 \text{ kwh}}{23\,000 \text{ sq. ft.}}$ = 0.30 kwh/sq.ft.

JOHNSTON HOUSE - JUNE 1982



$$\text{Average Daily Consumption} = \frac{18 - 15}{30 - 11} = 0.16 \text{ kwh/day}$$

$$\text{Yearly Consumption} = 0.16 \text{ kwh X } 260 \text{ (working days)}$$

$$= 42 \text{ kwh/year}$$

$$= \frac{42 \text{ kwh}}{2\ 300} = 0.02 \text{ kwh/sq. ft.}$$

Appendix 4

Information Transfer Activities

- Project Summary
- Tours
- Walk-in Visitors